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B.Baldin
H.Haggerty
S.Hansen

PDT Electronics Tests Using Cosmic Rays

We have completed a series of preliminary PDT Electronics tests with cosmic rays. A six foot standard muon PDT filled with fast gas mixture (Ar + 10%CH_4 + 10%CF_4) was used. Prototypes of the Front-End Board (FEB), Control Board (CB), Muon Readout Card (MRC) and fake Muon Fanout Card (MFC) were used in the test setup. A Motorola MVME166 processor was used as a VME master in a muon readout crate to control the MRC and MFC modules and also to interface with a host Unix machine via Ethernet. A block-diagram of the test setup is shown in Figure 1. Two scintillation counters SC1 and SC2 are used in coincidence to generate an external trigger signal. An eight-channel FEB prototype was connected to the PDT by twist-n-flat 34 wire 3M cables. A ‘data specific order’[/1/] of inputs was used to guarantee proper wire signal separation.

The FEB is configured after each power-up using a laptop PC’s parallel port. This is necessary until the final configuration of the Altera FLASHlogic chips (EPX740) is selected. Since the EPX740 devices are one time programmable, but configurable any number of times, they are loaded at power up until fully tested set of equations has been derived. The laptop PC also was used to download and communicate with the Control Board processors. A small monitor program resident in the RAM of the auxiliary DSP (ADSP-2111) has a basic set of operations that includes downloading of Intel hex formatted object files. Terminal emulator software running on the laptop was used to send code for a startup routine to the RS-232 port of the CB that configures both the FEB and the appropriate registers of the CB when run. The startup routine is menu driven and allows user to initialize both boards and setup hardware parameters.

The main processor (ADSP-21csp01) software was implemented in a PROM. The code running the main processor responds to requests by the auxiliary DSP thus enabling at least indirect control of both processors from the terminal port attached to the auxiliary DSP. The FEB-CB pair can be triggered in a variety of ways including an on-board test pulse generator, an external trigger source such as a scintillator coincidence of from the “OR” trigger bits present on the FEB.

When triggered, a hardware sequencer reads wire and pad data and does an initial set of reformatting steps. For the time being, the main DSP processor copies this data unaltered to the serial link transmitter (Cypress HOTLink CY7B923) with the addition of beam orbit and crossing numbers and global word count (level 3 data format)[/1/]. The buffering and data processing code for this DSP are under development by Northeastern University. The HOTLink receiver in the MRC receives the data in level 3 data format and stores it in a buffer memory. The MRC data buffer is read out by an MVME166 processor and is displayed in hex format on the terminal screen or stored in a file on the host. Software written in Fortran was used to further process data and plot histograms.

Typical coincidence trigger rate for scintillation counters of 20cm x 60cm size was about 10 Hz. Drift time and pad transfer gates were set to approximately 800 ns and 1500 ns respectively. The pipeline delay was adjusted to an arbitrary value of 1800 ns. The setup was carefully tested using internal FEB test pulsers. The typical threshold value for cosmic ray measurements was about 1 μA. Three types of measurements [/2/] have been made:

1) drift time of track ionization perpendicular to the chamber wire
2) transit time of the wire pulse longitudinally along the wire, and
3) charge ratio of the induced pulses on the shaped cathode pads.

The total drift time for the 5cm drift space is shown in Figure 2. The TMC bin width is ~1.2 ns, so the maximum drift time is about 500 ns. In order to measure the drift time resolution, the drift times in the top and bottom cells are combined and plotted versus the middle cell drift time. This procedure compensates for tracks at different angles. Figure 3 shows such a two-dimensional plot. A one-dimensional projection of this plot is shown in Figure 4. The calculated drift time resolution is about 7 ns, which corresponds to approximately 0.7 mm spatial resolution.

For the transit time measurements, a software trigger was generated at the CB using an “AND” of the three decks. The scintillation counters were not used in this case. In order to compensate for tracks at different angles, the top and bottom decks were combined and compared to the middle deck. Figure 5 shows the transition time scatter plot. Recall that the wires are connected at the “simple” end of each cell pair by a 20 ns delay. Figure 6 shows the transit time resolution, gotten by comparing the average of the top and bottom decks to the middle deck. The time resolution ~1.5 ns corresponds to a spatial resolution of approximately 20 cm. As per PDT design, the transit time determines the longitudinal position roughly; the charge ratio of the signal induced on the cathode pads gives the fine position. Again, by comparing the sum of top and bottom signals to the middle signal, Figure 7 shows scatter plot for charge pad ratios. Each ratio is defined by the following equation:

$$R = \frac{Q_a - Q_b}{Q_a + Q_b}, \text{ where}$$

Q_a and Q_b are the charges on the pads with the pedestals subtracted.

Figure 8 shows the fine resolution obtained by selecting a segment of Figure 7 that is independent of the track angle. The pad resolution measured by this method is about 0.5 cm.

References:

1. A.Khohlov et al., “Muon System Electronics Upgrade”, Technical Design Report, D0 Note 3299, July 22, 1997.
2. D.Green et al., “Accurate 2 Dimensional Drift Tube Readout Using Time Division And Vernier Pads”, Nucl. Instr. & Meth., A256 (1987), pp. 305-312.

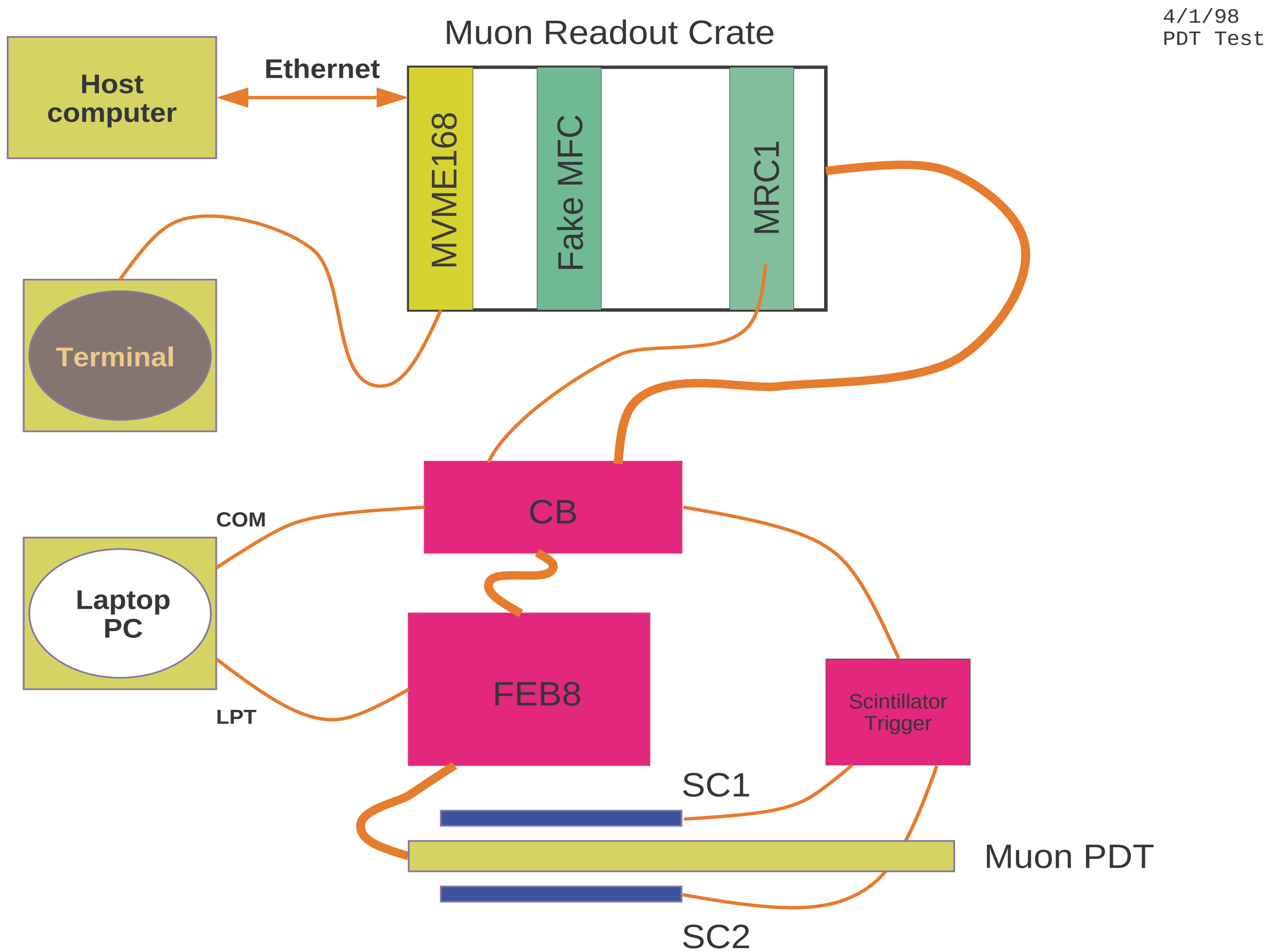

Figure 1. Muon PDT Electronics Test Setup.

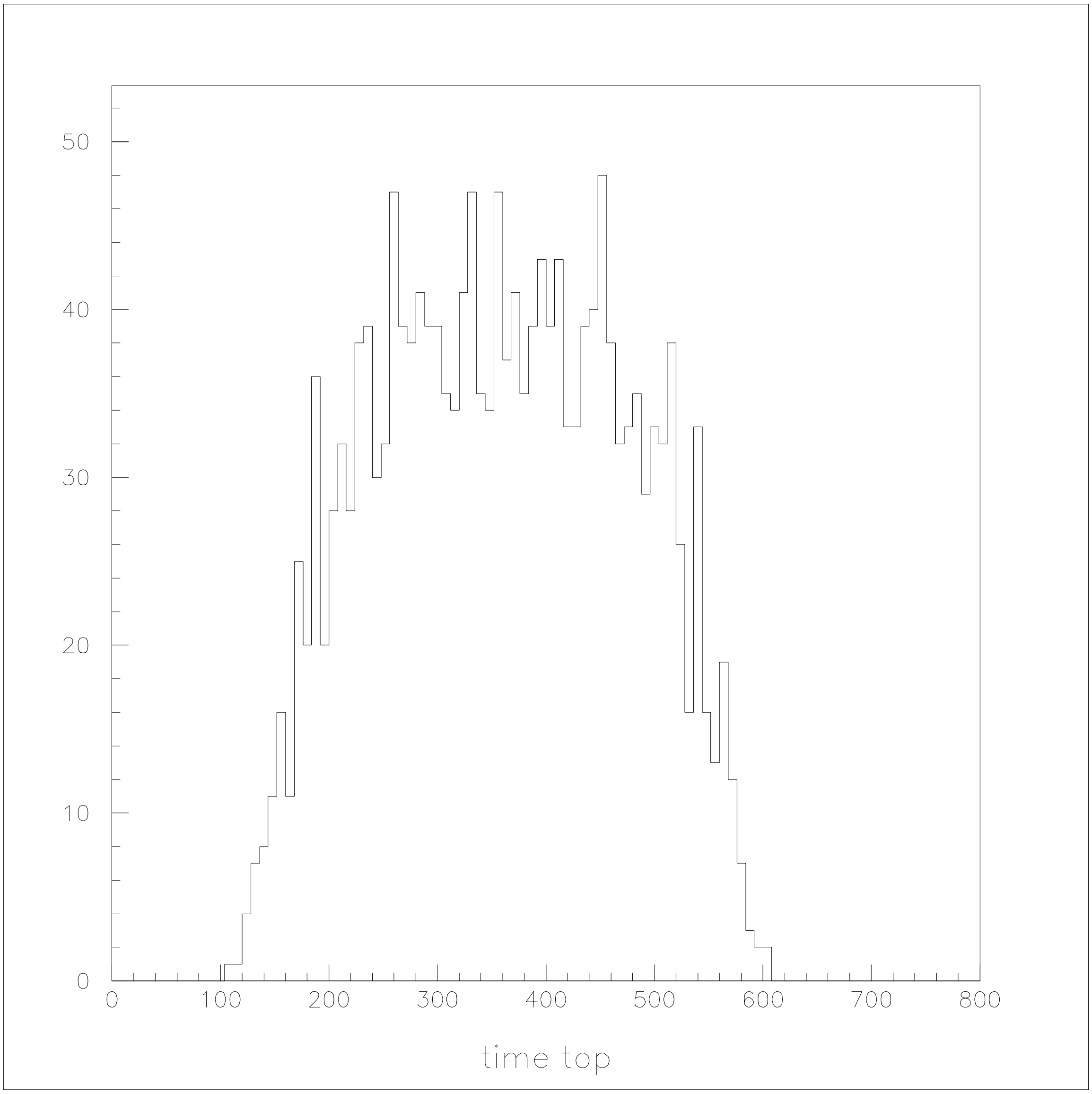

Figure 2. Drift time distribution for the top cell.

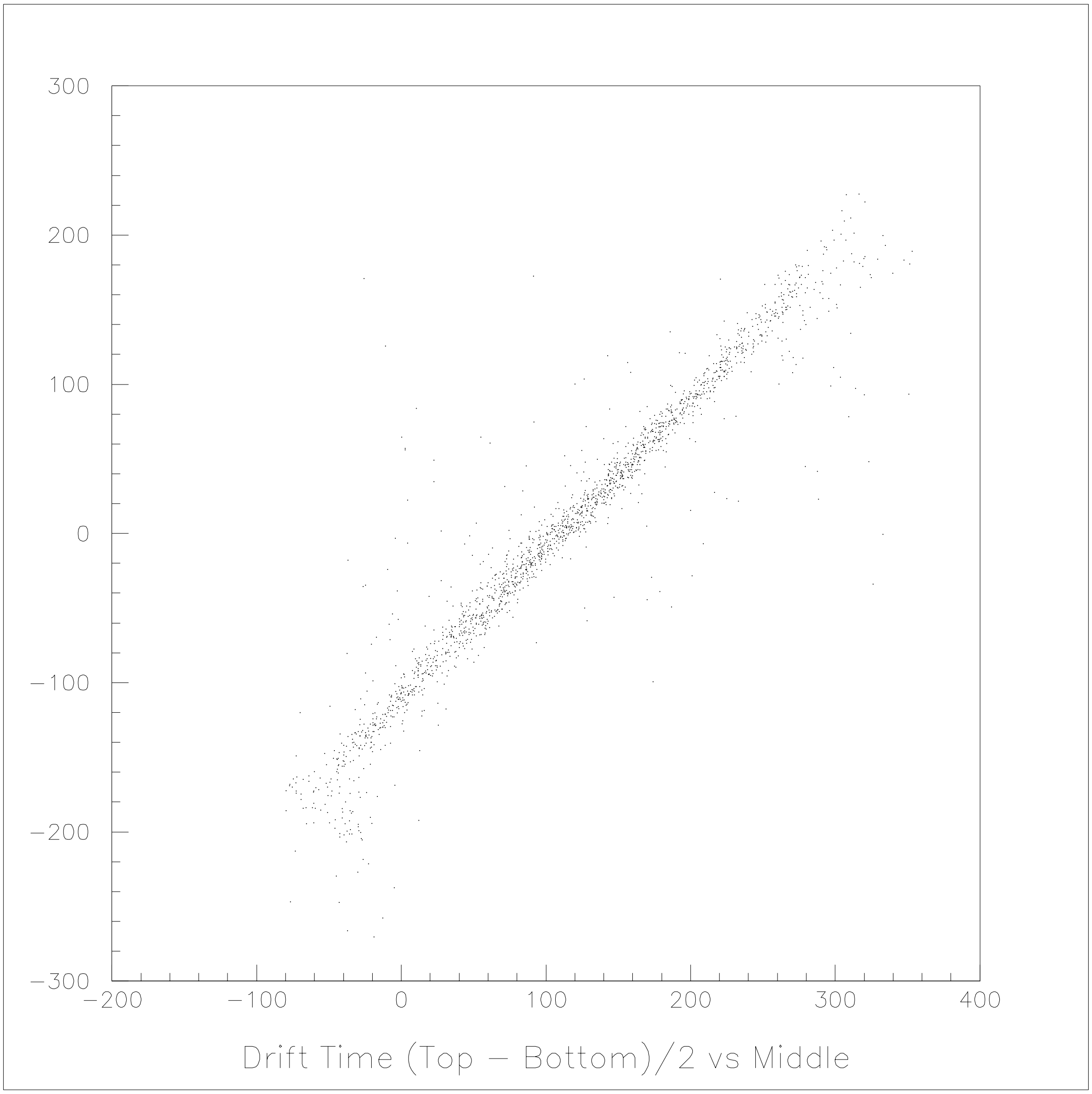

Figure 3. Drift time correlation.

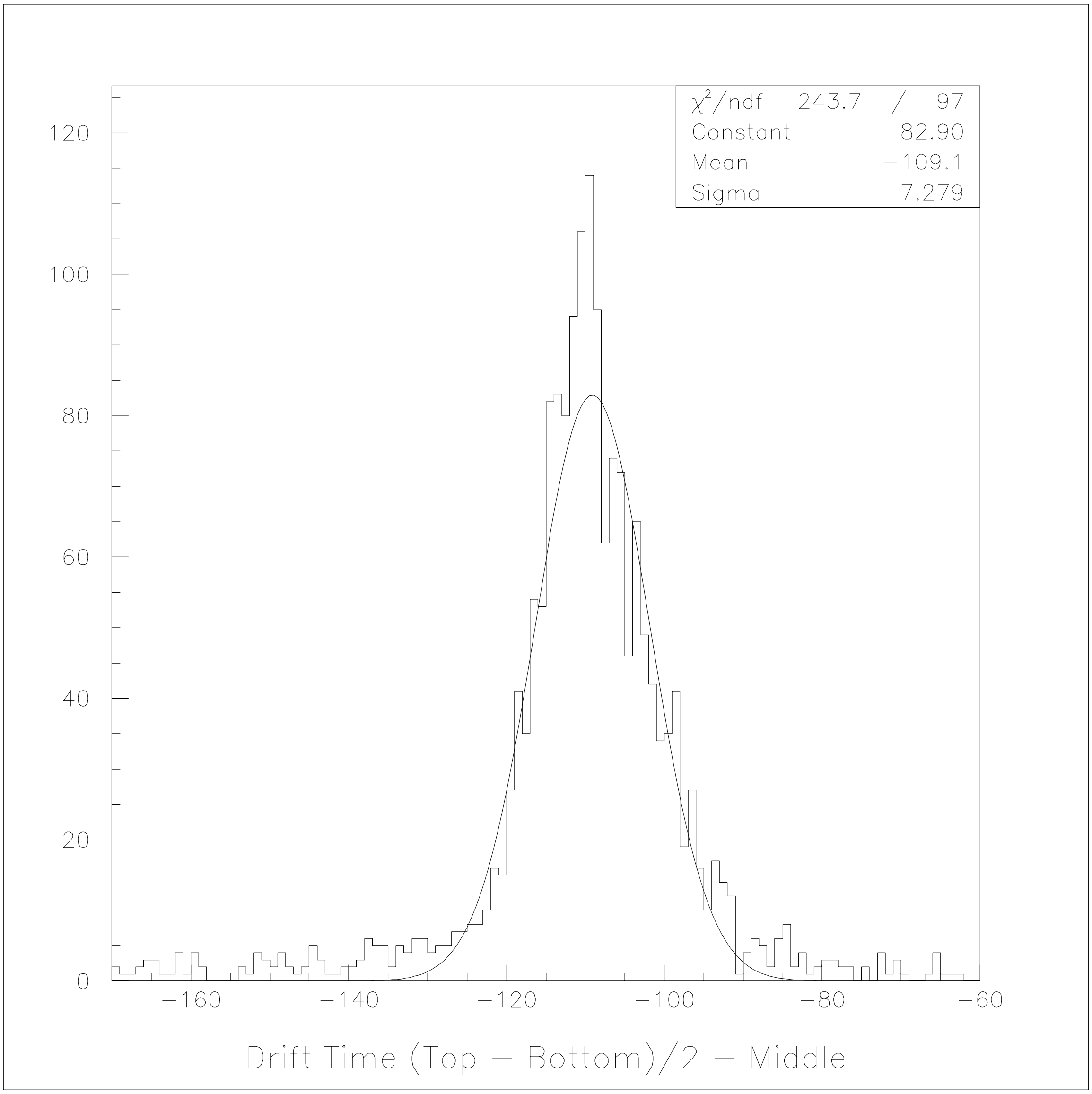

Figure 4. Drift time resolution projected from Figure 3.

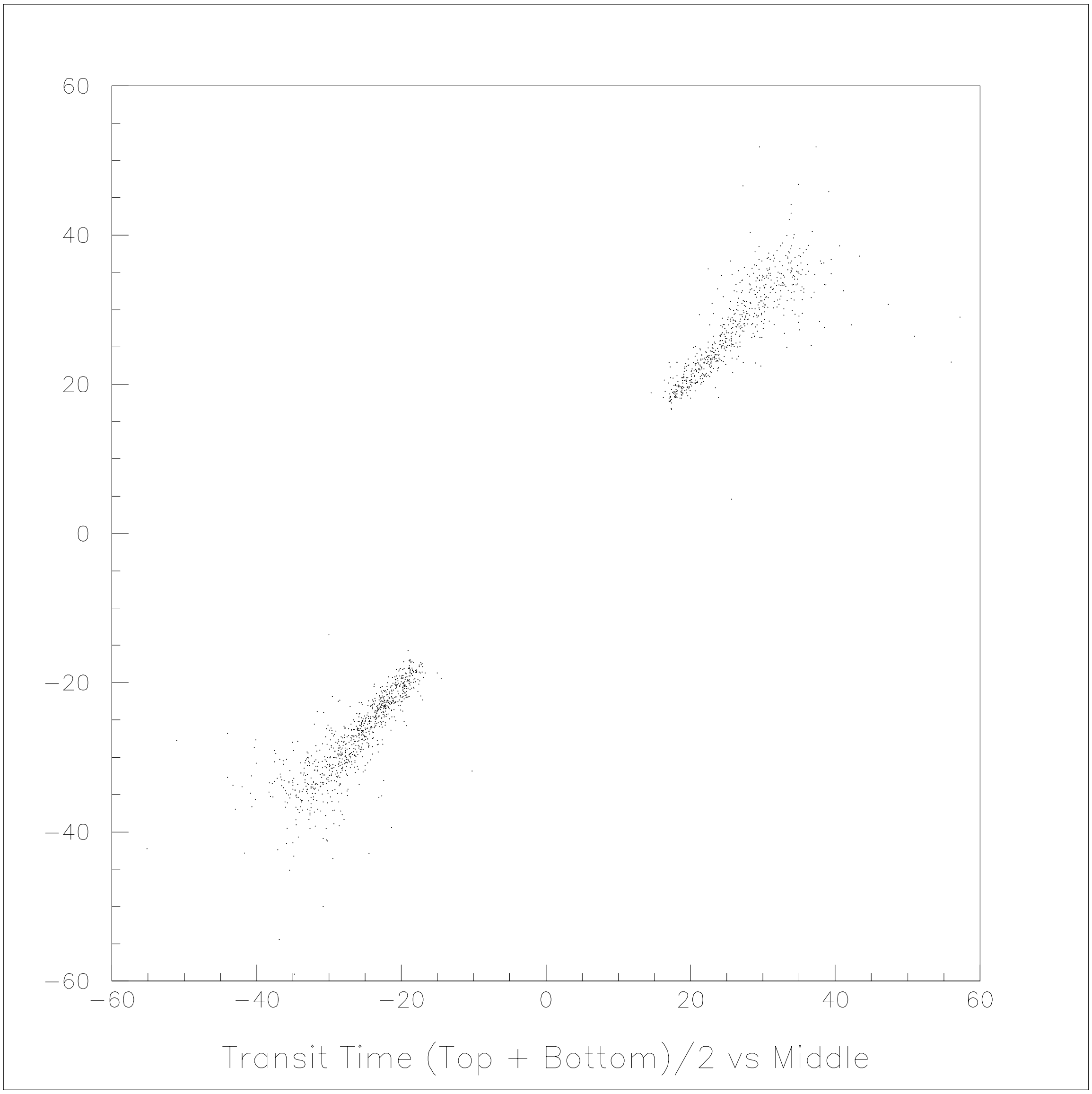

Figure 5. Transit time correlation.

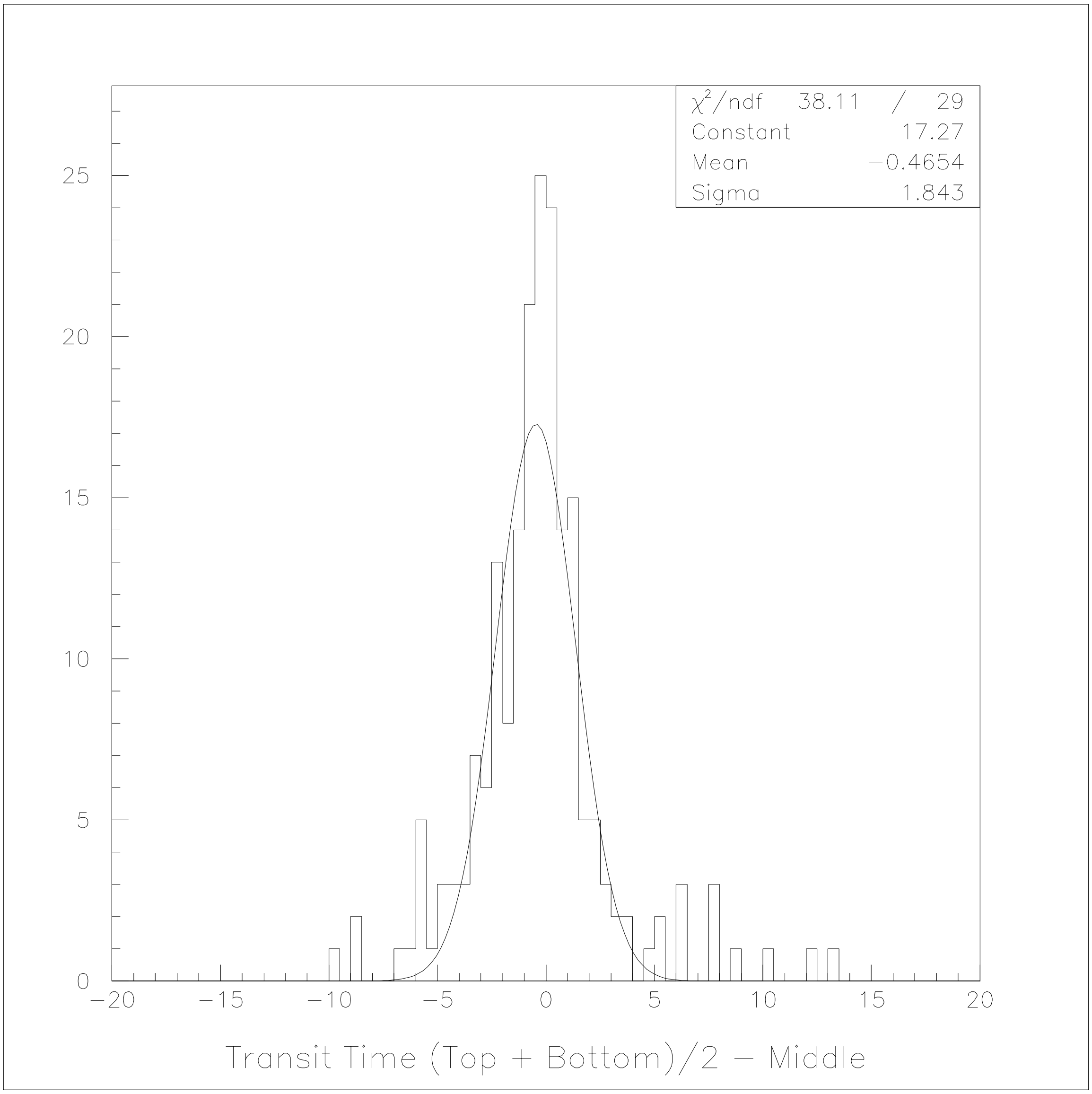

Figure 6. Transit time resolution projected from Figure 5.

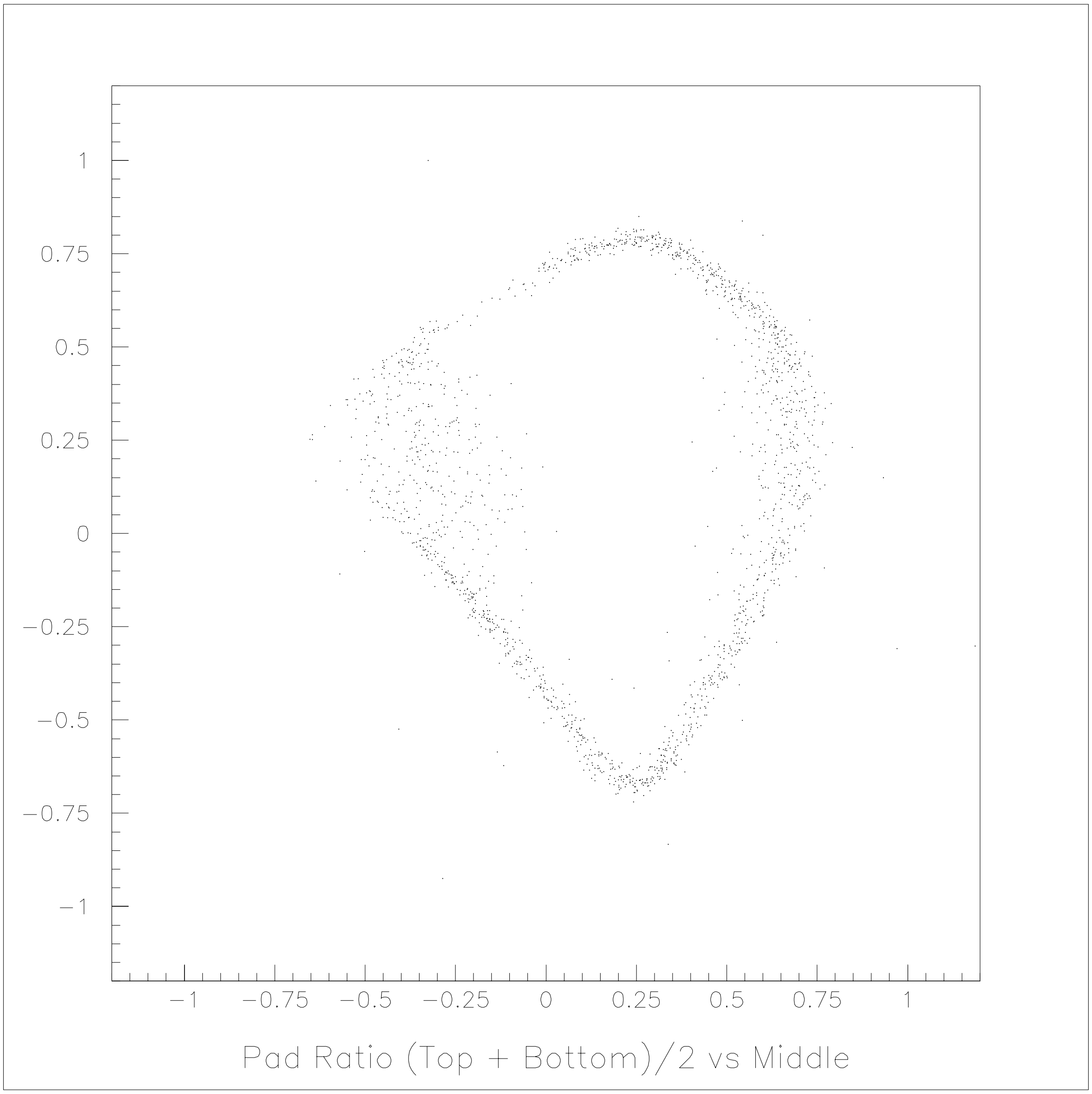

Figure 7. Pad ratio correlation.

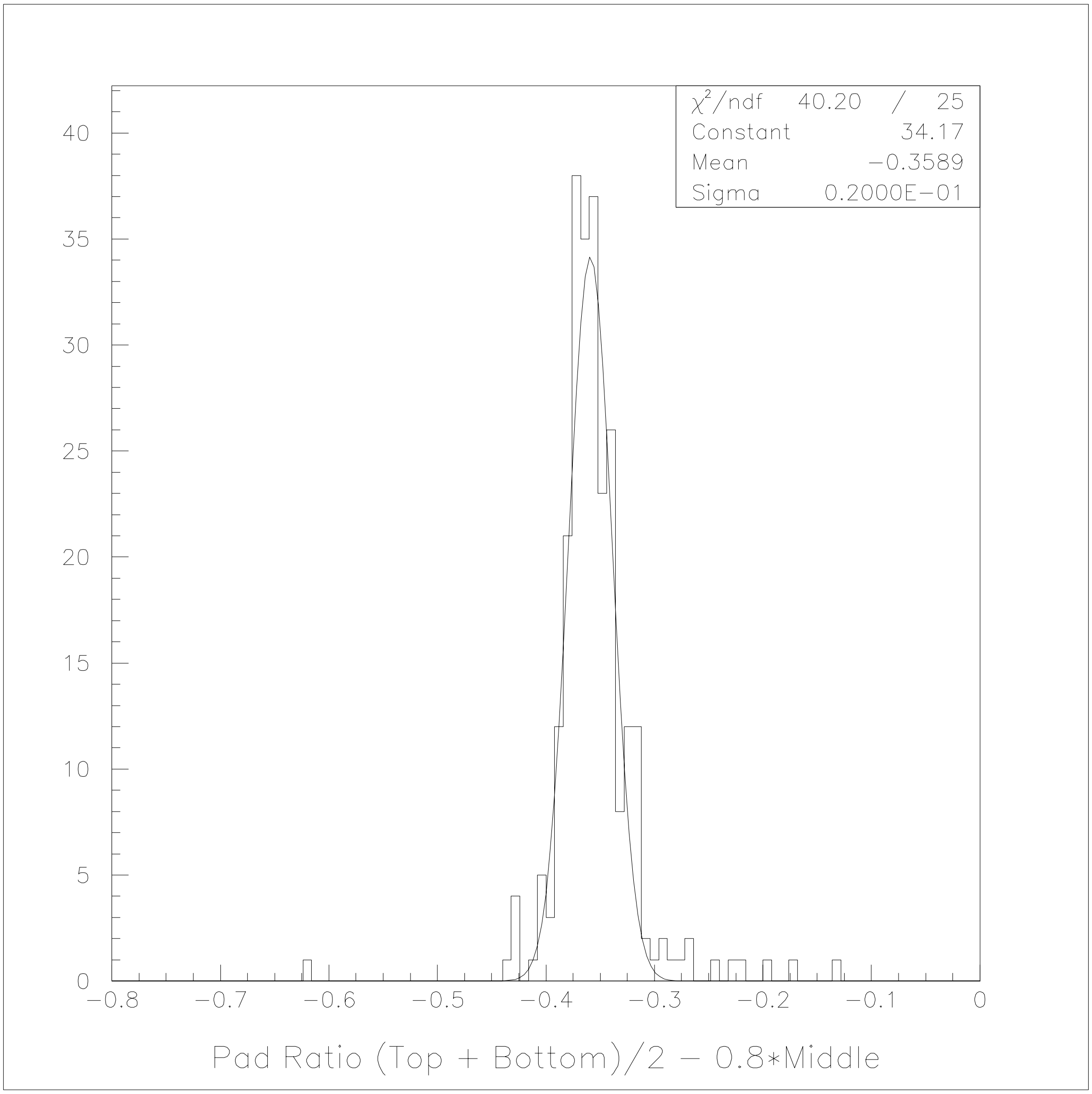

Figure 8. Pad resolution from selected projection of the plot in Figure 7.

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